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RESPONSE OF CHICKPEA (*CICER ARIETINUM L*) TO LAND PREPARATION METHODS AND SOWING DATES ON VERTISOLS OF SOUTHERN AND SOUTHEASTERN ETHIOPIA

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ABSTRACT

Vertisols are among the major high potential soils in Ethiopia covering about 13 million hectare (ha), but their productivity is constrained by severe water-logging due to their low permeability. Surface drainage technologies have been recommended and used for increased productivity. However, studies show that the performance of the technologies and level of adoption is site specific. This study was conducted over locations in 2010/11 and 2012/13 in southern and southeastern parts of Ethiopia, respectively to evaluate the performance of chickpea subjected to three land preparation methods: broad bed and furrows (BBF), ridge and furrows (RF) and flat seedbeds (FB) and two sowing dates (August 16 and September 3, 2010). Split-plot design with sowing dates as main plot and land preparation methods as sub-plot with four replications was used. Land preparation methods significantly ($P \leq 0.05$) influenced all agronomic parameters except days to flowering and days to physiological maturity at both sites. The highest number of pods per plant, grains per pod and grains per plant were obtained due to the use of broad bed and furrow, which gave the highest grain yield of 2,593 and 2,585 kg ha^{-1}, respectively at Taba and Chaffe Gugessa. These yield levels showed 204% and 204.8% more than that obtained under flat beds at Taba and Chaffe Gugessa, respectively. The effect of sowing date was also significant ($P \leq 0.05$) where early planting improved the number of pods per plant, grains per pod, biomass weight and harvest index at both sites. However, the percent crude protein content of grain showed variation over the experiment sites, where high protein obtained at Taba due to late planting but due to early planting at Chaffe Gugessa. The interaction effects of land preparation by sowing date were also significant ($P \leq 0.05$) on days to emergence, height at maturity, days to physiological maturity, number of pods per plant, grains per pod, biomass weight and grain yield. The highest biomass of 6801 kg ha^{-1} and 6785.8 kg ha^{-1} from RF plots at Taba and Chaffe Gugessa, respectively. Grain yields of 2791 and 2776 kg ha^{-1} were obtained when the crop was planted early on BBF at Taba and Chaffe Gugessa, respectively. Therefore, advancing planting date to mid-August and enhancing surface drainage using BBF significantly increased the productivity of chickpea grown on Vertisols.

KEYWORDS: Chickpea, Land Preparation Method, Sowing Dates, Surface Drainage, Taba, Chaffe Gugessa, Vertisols

INTRODUCTION

Vertisols are heavy clay soils with a high proportion of swelling and shrinking clay content which swell and shrink when wet and dry, respectively (WRB, 2006). These soils form wide cracks from the surface downward when they dry (FAO, 2001). Vertisols occupy over 335 million hectares (ha) or over 2.5% of the global land area (FAO, 2001), about 105 million ha in Africa and 12.7 million ha in Ethiopia (Gezahegn, 2001). Ethiopia ranks third in abundance of Vertisols in Africa after Sudan and Chad (Berhanu, 1985).

Despite the high natural fertility and positive response to management of Vertisols, some of their properties impose critical limitations on low input agriculture (FAO, 2001). The inherent limitations of Vertisols are largely a function of the moisture status of the soils and the narrow range of moisture conditions within which mechanical operations can be conducted (Jutzi, 1987). Vertisols in Ethiopia have high expanding lattice clay content (Berhanu, 1985) and the clay content and type of clay mineral (montmorillonite) make them difficult to work in both dry and wet conditions (ILCA, 1988). Consequently, they are regarded as marginal soils for crop production mainly due to land preparation problems at low moisture content and their sticky nature at high moisture levels (Hailu, 1992). Under the traditional management systems, yield from Vertisols is far below the potential (Berhanu, 1985). Broad bed and furrow (BBF) was recommended and disseminated as a means to overcome the problem of poor drainage to enhance productivity of crops sensitive to water-logging in the central highlands of the country (Teklu *et al.,* 2004).

Chickpea (*Cicer arietinum L*) is among the major crops in the farming systems of the highlands of Ethiopia, but sensitive to water-logging. Thus, to increase the productivity of crops and to exploit the potential of these soils, alternative land preparation methods and suitable sowing dates should be identified for specific crops including chickpea that are widely grown on Vertisols in different agro-ecologies in the country (Berhanu, 1985). Early planting and improved surface drainage with appropriate cropping systems are believed to increase crop productivity on Vertisols (FAO, 2001). A report by Kaya *et al.* (2010) also indicated that delaying chickpea planting significantly decreased yield and yield components of the crops.

During the 2009/2010 cropping season, chickpea accounted for over 14% of the total pulse production in Ethiopia with an average yield of about 1,300 kg ha^{-1} and covered over 213,000 ha of land (CSA, 2010). The crop is grown in several regions of the country. However, its production is mainly concentrated in Shoa, Gojam, Tigray, West Wollo, Gonder, East Bale and West Hararghe areas within the altitude range of 1400-2300 meters above sea level (masl) and annual rainfall of 700-2000 mm (Geletu *et al.,* 1996).

Water-logging is among the major problems posing conspicuous impediments to chickpea production on Vertisols in different parts of the highlands including Wolaita and Arsi Zones, sometimes leading to crop failure due to root rot and highly reduced aeration problems. Thus, chickpea is essentially grown after harvesting the main crops on residual moisture, which often exposes the crop to drought during its active phenological growth stage such as fruit and seed setting (Geletu and Yadeta, 2002).

In the study areas, the use of BBF for improving drainage conditions is not common. Rather, planting chickpea at the end of the rainy season on flat bed, hopping the residual moisture suffice, is a common practice. On top of that, the optimum sowing date for chickpea has not been established scientifically. This study was therefore initiated with the objective to evaluate the response of chickpea to selected land preparation methods meant for improved surface drainage and to sowing dates.

MATERIALS AND METHODS

Location and Climate of the Study Areas

The experiment was conducted at two experiment sites: Taba Watershed in the Damot Gale District of Wolaita Zone, southern and at Chaffe Gugessa watershed in Digalu Tijo District of southeastern Ethiopia. The geographical location of the Watersheds is $06^0\ 57'$N latitude and $37^0\ 54'$ E longitudes; $7^o20'$ N latitude and $39^o15'$ E longitude with elevation of 1850 and 2550 masl, respectively. The areas are characterized by an average annual rainfall of 1180 mm and

1250 mm; and mean annual temperature of 19.1 ^{0}C and 17.5 ^{0}C, respectively.

Soils of the Study Areas

For the purpose of this experiment, soil samples from 24 spots at a depth of 0-30 cm were collected from both Taba and Chaffe Gugessa watersheds using auger method to make a composite sample that represents the experimental site before planting. The auger sampled soil was mixed thoroughly, air dried, thoroughly mixed and ground to pass through a 2 mm sieve for analysis of some physical and chemical properties and through 0.5 mm for organic carbon (OC) and total nitrogen (N) analysis. Core sampling method was also employed for the determination of soil bulk density. The results of the analysis on the properties of the soil are indicated in Table 1.

Table 1: Major Characteristics of the Soil at the Experimental Site

Soil Characteristics	Taba Watershed	Chafa Gugessa
Sand (%)	19	16
Silt (%)	44	41
Clay (%)	37	43
Textural class	Silty clay loam	Silty clay
Permanent wilting point (mm)	235.80	238.60
Field capacity (mm)	382.20	396.20
Available water holding capacity (mm)	146.40	157.60
Bulk density (g cm^{-3})	1.22	1.21
pH (1:2.5 soil : water ratio)	6.70	6.80
Organic matter (%)	1.87	1.84
Total nitrogen (%)	0.12	0.11
Available phosphorus (mg kg^{-1})	1.90	1.70
Exchangeable potassium (cmolc kg^{-1} soil)	0.07	0.07
Cation exchange capacity (cmolc kg^{-1} soil)	27.20	29.30

Experiment Setup

The experiment was laid out in a split-plot design with four replications, with the sowing dates as main plots and land preparation methods as sub-plots. The areas of each sub plot, main plot and area used for one sowing date were 19. 2, 57.6 and 230.4 m^2, respectively at both experimental sites. The spacing between main plots and sub-plots were 0.8 and 0.4 m, respectively. A chickpea variety called "*Arerti*" characterized by cream white color, relatively late maturing and fusarium wilt (ICRISAT and EIAR, 2009) and Ascochyta blight (www.eap.gov.et/index.php?q=node/462, Accessed July, 2010) resistant Kabuli chickpea was used as a test crop.

Treatments

Three sowing dates (16th of August, 3rd of September and 1st October) and three land preparation methods namely, broad bed furrow (BBF), ridge furrow (RF) and flat bed (FB) constituted the treatments. The BBFs were constructed with an effective raised bed width of 0.8 m and 0.20 m dead furrows; this is intended to facilitate surface drainage through the furrows between the beds so that the crops grow on the raised beds. Each BBF plot consisted of raised beds of 80 cm width and 6 m length. The RFs were also constructed with an oxen-drawn traditional wooden plow such that the crops grow on the ridges, permitting the excess water to drain out of the field through the furrows. These are parallel narrow structures of about 0.20 m raised and 0.20 m width. In the RF plots, 8 ridges each of 20 cm width with 6 m length were used. The FBs, commonly used in the area constitute nine rows with 30 cm space between rows and 10 cm between plants and were considered as the control treatment of the experiment.

Cultural Practices

Land preparation started immediately after the harvest of the belg (spring) season maize crop (early June) so that weeds were removed and the land was smoothened. Two times plowing before the actual sowing time was practiced. For the practice of row planting, seed rate of 150 kg ha^{-1} was used. Twice hand weeding (at 30 and 60 days after emergence of seedlings) was conducted. In order to initiate the growth of the plant, 18 kg of N and 46 kg of P_2O_5 ha^{-1} were used at planting time through placement method of approximately 5 cm away and below the seed (www.eap.gov.et/index.php?q=node/462, Accessed July, 2010).

Data Analysis

The agronomic and yield data collected during the course of the study were subjected to analysis of variance (ANOVA) using the general linear model procedure of SAS software version 9.1 (SAS Institute, 2001). The least significant difference (LSD) test was used to separate significantly differing treatment means after they were found significant at $P \leq 0.05$.

RESULTS AND DISCUSSIONS

Crop Phenology and Growth Parameters

The interaction effect of sowing dates and land preparation methods on days to seedling emergence was statistically significant ($P \leq 0.05$) at both sites, indicating that the effect of either factor on this parameter is dependent on the effect of the other factor (Tables 2 and 3). The highest number of days to seedling emergence at both sites was taken by the crops sown on August 16 on FB and the crops sown on September 3 on RF (Table 3). This might be due to aeration problem that negatively impacted plant emergence in the case of the former and due to moisture stress on the bed in the latter case. However, the effect of sowing date on the emergence of the plant was not significant (Table 2) at both sites.

Table 2: Treatment Effects on Plant Emergence, Flowering and Height

	Taba			Chaffe Gugessa		
Treatment*	**DE (Days)**	**DF (Days)**	**PH (cm)**	**DE (Days)**	**DF (Days)**	**PH (cm)**
SD	**Effects of Land Sowing Dates**					
16-Aug	6.42a	69.83[a]	38.55a	6.75a	69.83a	38.57a
3-Sep	6.92a	65.08[b]	36.18b	7.17a	65.25b	36.27b
LSD (0.05)	ns	3.79	1.09	ns	3.02	1.39
LPM	**Effects of Land Preparation Method**					
Flat bed	7.13a	70.75a	35.51c	6.63b	69.25a	35.56c
BBF	6.00b	69.12a	39.28a	6.75b	68.25ab	39.34a
RF	6.88a	64.75a	37.29b	7.50a	65.13b	37.35b
LSD (0.05)	0.52	NS	1.16	0.73	3.7	2.00
CV (%)	7.07	6.21	2.84	9.99	5.19	4.31

* Means within a column and the same factor followed by the same letter are not significantly different at $P > 0.05$. ED = Days to emergence; DF = Days to flowering; PH = Plant height; LPM = Land preparation method; SD = sowing date; BBF = Broad bed and furrow; RF = Ridge and furrow; LSD = Least significant difference; CV = Coefficient of variation; ns = Not significant

Days to flowering was significantly ($P \leq 0.05$) influenced by the main effect of sowing dates (Tables 2) at both sites. The crops sown on August 16 took longer days (about 70 days at both sites) as compared to those sown on September 3 which took 65 days to flower (Table 2). This was mainly due to high available moisture in the soil. These findings were in agreement with the results reported by Geletu *et al.* (1997) that other than sowing dates, bed types had no significant

influence on days to 50% flowering of chickpea. Similarly, land preparation methods had also showed significant ($P \leq 0.05$) difference among days to flowering at both sites.

Table 3: Land Preparation and Sowing Dates Interaction Effects on Plant Emergence and Height

	Taba				Chaffe Gugessa			
Land Preparation Method	**Days to Emergence**		**Plant Height (cm)**		**Days to Emergence**		**Plant Height (cm)**	
	16-Aug	**Sept. 3**	**16-Aug**	**Sept. 3**	**16-Aug**	**Sept. 3**	**16-Aug**	**Sept. 3**
FB	7.3a	7.0ab	35.2d	35.8dc	6.3b	7.0ab	35.2d	35.9cd
RF	6.5b	7.3a	39.1b	35.5d	7.0ab	8.0a	39.2b	35.6d
BBF	5.5c	6.5b	41.3a	37.3c	7.0ab	6.5ab	41.4a	37.3c
Mean	6.4	6.9	38.6	36.2	6.8	7.2	38.6	36.3
$LSD_{(0.05)}$	0.7		1.6		1.56		1.64	
$CV_{(\%)}$	7.3		2.8		15.05		2.95	

* LSD = Least significant difference; CV = Coefficient of variation; Sept. = September

Treatments and their interaction effects significantly ($P \leq 0.05$) influenced plant height at maturity (Table 2 and 03). Plant height measured at maturity ranged from about 35 cm at FB practiced on August 16 to 41 cm at BBF practiced on the same sowing date at both sites (Table 4). This may be due to water logging on the FB that might have caused poor aeration, which in turn resulted into limited height of the plant grown, while draining excess water from the plot helped the plant grown on BBF to use good vegetative growth period and made to have the highest height. Similar results were reported by Geletu *et al.* (1997) and Teklu *et al.* (2004) that land preparation types have significant effect on plant height at maturity.

Table 4: Treatment Effects on Days to Plant Maturity Pods and Seed per Pod

	Taba			Chaffe Gugessa		
Treatment*	**DM (Days)**	**Pods Plant^{-1}**	**Seeds Pod^{-1}**	**DM (Days)**	**Pods Plant^{-1}**	**Seeds Pod^{-1}**
SD		**Effects of Land Sowing Dates**				
16-Aug	123.9a	91.7a	1.5a	123.3a	92.2a	1.49a
3-Sep	115.6b	87.1b	1.4a	115.4b	87.1a	1.46a
LSD (0.05)	4.87	2.7	ns	4.93	ns	ns
LPM		**Effects of Land Preparation Methods**				
Flat bed	121.6a	69.7b	1.3b	121.3a	59.2b	1.26b
BBF	121.8a	101.5a	1.6a	121.3a	102.7a	1.63a
RF	115.9a	96.9a	1.5a	115.6a	96.9a	1.54a
LSD (0.05)	NS	5.98	0.16	NS	11.17	0.14
CV (%)	4.57	6.14	10.32	4.99	11.81	8.77

* DM = Days to maturity;

The result showed that interaction effect of the treatments significantly ($P \leq 0.05$) influenced days the crop to get matured. Days to 90 % maturity of the plant ranged from 108.5 days at RF practiced on September 3 sowing date to 127 days at BBF practiced on August 16 sowing date at Taba and with slight difference of 108.3 and 126 days at Chaffe Gugessa (Table 5). This may be due to relatively high temperature and low moisture status of the soil that hasten maturity period of the plant grown on RF plot for sowing in September, while relatively high moisture and low temperature condition during sowing on August 16 allowed the crop grown on BBF plot to consume maximum days for vegetative growth. However, land preparation methods showed no significant influence on days to maturity at both sites (Table 4). Similar findings were reported earlier by Onyari *et al.* (2010) that early planted chickpea was resulted in to late maturity while late planted into early maturity.

Table 5: Treatment Interaction Effects on Plant Days to Maturity

Treatment*	Taba		Chaffe Gugessa	
	Days to Maturity		Days to Maturity	
	16-Aug	Sept. 3	16-Aug	Sept. 3
FB	121.5ab	122.ab	121.0ab	121.5ab
RF	123.3ab	108.5c	123.0ab	108.3c
BBF	127.0a	116.5b	126.0a	116.5b
Mean	123.9	115.6	123.3	115.4
LSD $_{(0.05)}$	7.4		6.9	
CV $_{(\%)}$	4.1			3.9

Yield Components and Yield

Number of pods per plant at both sites was significantly ($P \leq 0.05$) influenced by the treatments interaction effects (Table 4). The mean number of pods at Taba ranged from 107.5 for the first planting date on BBF to 61.3 for the first planting date on FB, while planting on BBF on August 16 was a bit greater at Chaffe Gugessa (109.9) compared to the site one (Figure 2). This implies that the excess water on the FB might have considerably affected the crop during the period of pod formation. On the other hand, the removal of excess water from BBF plot might have resulted into well aeration and conducive pod formation conditions.

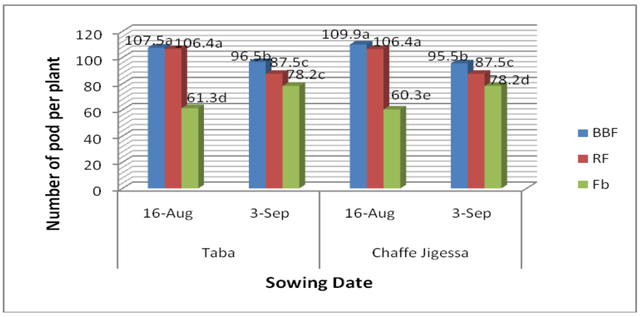

Figure 1: Interaction Effects of Land Preparation Methods and Sowing Dates on Pods per Plant

*Note that bars followed by the same letter are not statistically different at $P > 0.05$.

The influence of sowing dates was not significant ($P > 0.05$) on the number of grains per pod (Table 4). However, the main effects of land preparation methods significantly ($P \leq 0.05$) affected the number of grains per pod, where maximum (about 1.6) grains from the BBF was recorded at both sites.

Treatments and their interaction effects significantly ($P \leq 0.05$) influenced the yield of above ground biomass at both experiment sites (Table 5 and Figure 2). The biomass yield ranged from 6801.3 kg ha^{-1} from BBF and sown on August 16 to 2867.7 kg ha^{-1} from FB and sown on August 16 (Figure 3) at Taba; and 6785.8 kg ha^{-1} from RF and sown on August 16 to 2861.3 kg ha^{-1} from FB and sown on August 16 at Chaffe Gugessa. This indicates that sowing chickpea on August 16 on BBF plot gives the highest biomass yield than other land preparation methods. This may be due to comparatively longer vegetative growth period used by the crop sown on BBF during August 16. The yield from FB was the least in all treatments, which may be due to the water logging problem that limited aeration, root and vegetative growth condition. These results are in line with the findings of Onyari *et al.* (2010), who reported that the biomass yield of chickpea was significantly influenced by sowing dates. Similar result on the effect of BBF on straw yield was reported by Teklu *et al.* (2004).

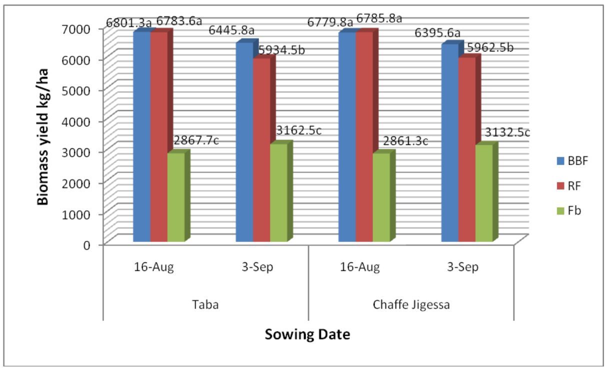

Figure 2: Interaction Effects of Land Preparation Method and Sowing Date on Biomass Weight

Interaction effects of land preparation methods and sowing dates also significantly ($P \leq 0.05$) influenced the grain yield (Figure 3) at both sites. The highest mean yields of 2791.2 and 2775.8 kg ha^{-1} due to the first planting date on BBF and while the lowest yields of 725.8 and 725.0 kg ha^{-1} were obtained due to the first planting date on FB (Table 5) at Taba and Chaffe Gugessa, respectively. These show that the yields from BBF were high when practiced in early sowing time (16 August) than in late sowing (3 September). Broad bed and furrow increased grain yield by 204 and 7.2% compared to the FB and RF at Taba and 204.7% and 7.5% at Chaffe Gugessa, respectively (Table 5). This may be due to the removal of excess water and increased effective bed area of the BBF. The use of BBF for effectively increasing crop yield compared to other conventional RF and FB drainage methods was also proved by the report of Gezahegn (2001). Teklu *et al.* (2004) also reported significant effect of BBF on grain yield as compared to RF and FL.

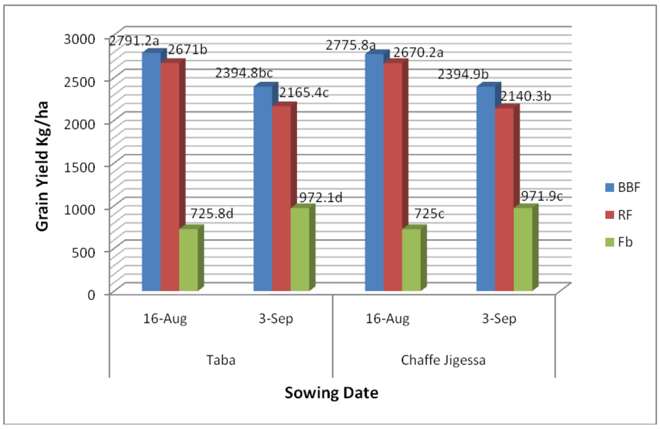

Figure 3: Interaction Effects of Land Preparation Method and Sowing Date on Grain Yield

Harvest index (HI) was significantly ($P \leq 0.05$) influenced by the main effects of land preparation methods (Table 6) at both sites. This is mainly due to the fact that HI is dependent on the ratio of grain yield to biomass yield. Sowing dates also significantly ($P \leq 0.05$) influenced the HI (Table 6) at Taba, but had no significant effect at Chaffe Gugessa. Higher HI value was recorded from sowing date one (37%) at Taba. Therefore, early sowing on August 16 increased HI by 5.35% compared to late sowing on September 3. The reason behind this might be the longer vegetative growth and grain filling period utilized by crop sown on August 16, which resulted into higher yield that in turn resulted into higher harvest index. Relationship between harvest index and sowing dates has been reported by other researchers. Yeneneh (2006) and Kaya *et al.* (2010) reported that sowing date has significant effect on HI of chickpea.

Table 6: Effects of Sowing Dates and Land Preparation Types on Yield Components and Yield

Treatment*	Taba			Chaffe Gugessa		
	Biomass Yield (kg ha^{-1})	Grain Yield (kg ha^{-1})	Harvest Index	Biomass Yield (kg ha^{-1})	Grain Yield (kg ha^{-1})	Harvest Index
SD	**Effects of Sowing Date**					
16-Aug	5485.50a	2062.67a	0.37a	5475.7a	2057a	0.35a
3-Sep	5180.96b	1844.09a	0.34b	5163.5a	1835.7a	0.35a
LSD $_{(5\%)}$	291.68	NS	3.6	NS	NS	NS
LPM	**Effects of Land Preparation Methods**					
BBF	6625.5a	2593.00a	0.40a	6587.7a	2585.3a	0.39a
RF	6359.0a	2418.19a	0.39a	6374.2a	2405.3a	0.38a
Flat bed	3015.1b	848.95b	0.28b	2996.9b	848.4b	0.28b
LSD $_{(5\%)}$	357.23	193.91	4.44	398.83	279.25	5.04
CV $_{(\%)}$	6.15	9.11	11.37	7.11	13.61	13.62

*Means within a column and the same factor followed by the same letter are not significantly different at P > 0.05.

The main effect of land preparation methods on the 100 grain weight was found to be significant (P ≤ 0.05) at both sites (Table 7). Growing chickpea on BBF and RF plots increased the weight of the grain by about 1.53 and 1.05 g compared to the conventional FB plot at Taba and Chaffe Gugessa, respectively. The reason for such variation may be due to the removal of excess water from the beds which might have helped the drained plots to produce bigger grains as compared to the FB. Onyari *et al.* (2010) also found that tillage method significantly influenced the 100 grain weight of chickpea grown in Kenya. . However, this result is in contrary to the findings of Geletu *et al*. (1997) that bed types had no significant influence on 100 seed weight. The yield of crude protein content of the crop was significantly (P ≤ 0.05) influenced by the effects of both land preparation types and sowing dates at both sites (Table 7). The highest protein content of 23.68% and 23.7% were recorded from BBF at Taba and Chaffe Gugessa, respectively (Table 7). Compared to the FB plot, about 4.45 and 4.02% increments were caused due to the use of BBF at both sites, respectively.

Table 7: Effects of Sowing Dates and Land Preparation Types on Yield Quality

Treatment*	Taba		Chaffe Gugessa	
	100 Grain Weight (g)	Crude Protein (%)	100 Grain Weight (g)	Crude Protein (%)
SD	**Effects of Sowing Date**			
16-Aug	27.95a	21.29b	27.58a	22.96a
3-Sep	26.44a	22.98a	26.91a	21.64b
LSD (5%)	NS	1.69	NS	1.1
LPM	**Effects of Land Preparation Methods**			
BBF	27.96a	23.68a	27.75a	23.70a
RF	27.2ab	`23.51a	27.29a	23.53a
Flat bed	26.43b	19.23b	26.70a	19.68b
LSD (5%)	1.13	2.07	NS	1.34
CV (%)	3.81	8.58	5.71	3.98

*Means within a column and the same factor followed by the same letter are not significantly different at P > 0.05. LPM = Land preparation method; SD = sowing date

Similarly, sowing dates significantly (P ≤ 0.05) influenced protein content of the grain at both sites (Table 7). Higher protein content was due to the second sowing date (22.98%) as compared to 21.29%, which was obtained due to the first sowing date in the case of Taba, but 22.96% was recorded from the first sowing date at Chaffe Gugessa (Table 7). These values revealed that delayed sowing increased protein content by about 1.69% compared to the earlier sown plant at

Taba whereas it reduced by 1.32% at Chaffe Gugessa. This variation may be due to moisture stress and relatively high temperature during the growing season of the plant sown on September 3 that cause reduction in dry matter accumulation there by reducing dilution of N in the grain. However, as the total grain yield ha^{-1} of the crop sown on August 16 was higher, the total grain protein yield obtained was also higher at both sites. These results came in a good agreement with the result obtained by Kaya *et al.* (2010), who reported higher grain protein from delayed sowing.

CONCLUSIONS

Broad bed and furrow was superior over the other land preparation methods, especially on yield and yield components, revealing that the practice of improved land preparation method on Vertisols enables to achieve higher yields. Early planting also enabled the plant to use longer vegetative and grain filling time and resulted in to higher yield. Thus, based on the findings of the two seasons at two sites, it can be recommended that the use of BBF combined with sowing in mid-August is worth testing by development agents in farmers training centers as well as by farmers.

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